RET trajectory. Magnetic Resonance in Medicine. 2017; 78(3):1038-49. PubMed PMID: WOS: 000407855700022.

[0220] 52. Zwart N R, Pipe J G. Graphical programming interface: A development environment for MRI methods. Magnetic Resonance in Medicine. 2015; 74(5):1449-60. PubMed PMID: WOS:000364215900026.

[0221] 53. Pipe J G, Zwart N R, Aboussouan E A, Robison R K, Devaraj A, Johnson K O. A New Design and Rationale for 3D Orthogonally Oversampled k-Space Trajectories. Magnetic Resonance in Medicine. 2011; 66(5):1303-11. PubMed PMID: WOS:000296389800011.

[0222] 54. Willmering M M, Robison R K, Wang H, Pipe J G, Woods J C. Implementation of the FLORET UTE sequence for lung imaging. Magnetic Resonance in Medicine. 2019; 82(3):1091-100. doi: 10.1002/mrm.27800.

[0223] 55. Willmering M M, Niedbalski P J, Wang H, Walkup L L, Robison R K, Pipe J G, Cleveland Z I, Woods J C. Improved pulmonary 129Xe ventilation imaging via 3D-spiral UTE MRI. Magnetic Resonance in Medicine.n/a(n/a). doi: 10.1002/mrm.28114.

[0224] 56. Niedbalski P J, Willmering M M, Robertson S H, Freeman M S, Loew W, Giaquinto R O, Ireland C, Pratt R G, Dumoulin C L, Woods J C, Cleveland Z I. Mapping and correcting hyperpolarized magnetization decay with radial keyhole imaging. Magnetic Resonance in Medicine. 2019; DOI: 10.1002/mrm.27721. doi: 10.1002/mrm. 27721.

[0225] 57. Guo J, Hardie W D, Cleveland Z I, Davidson C, Xu X, Madala S K, Woods J C. Longitudinal free-breathing MRI measurement of murine lung physiology in a progressive model of lung fibrosis. Journal of Applied Physiology. 2019; 126(4):1138-49. doi: 10.1152/japplphysiol.00993.2018. PubMed PMID: 30730810.

[0226] 58. Higano N S, Hahn A D, Tkach J A, Cao X F, Walkup L L, Thomen R P, Merhar S L, Kingma P S, Fain S B, Woods J C. Retrospective Respiratory Self-Gating and Removal of Bulk Motion in Pulmonary UTE MRI of Neonates and Adults. Magnetic Resonance in Medicine. 2017; 77(3):1284-95. doi: 10.1002/mrm.26212. PubMed PMID: WOS:000397407800038.

[0227] 58. Diggle, P. J., Sousa, I., Asar, O. (2015). Real-time monitoring of progression towards renal failure in primary care patients. Biostatistics, 16(3): 522-36. DOI: 10.1093/biostatistics/locu053.

[0228] Jiang, C.-R., Wang, J.-L. (2010). Covariate-adjusted functional principal components analysis for longitudinal data. The Annals of Statistics, 38(2): 1194-1226.

[0229] 59. Szczesniak, R., McPhail, G. L., Duan, L. L., Macaluso, M., Amin, R. S., Clancy, J. P. (2013). A semiparametric approach to estimate rapid lung function decline in cystic fibrosis. Annals of Epidemiology, 23(12): 771-7. DOI: 10.1016/j.annepidem.2013.08.009. PMID: 24103586.

[0230] 60. Szczesniak, R., Li, D., Su, W., Pestian, J., Seid, M., Clancy, J. P. (2017). Phenotypes of Rapid Cystic Fibrosis Lung Disease Progression during Adolescence and Young Adulthood. American Journal of Respiratory and Critical Care Medicine, 196(4): 471-478. DOI: 10.1164/rccm.201612-25740C. PMID: 28410569

[0231] 61. Yao, F., Muller, H.-G., Wang, J.-L. (2005). Functional Data Analysis for Sparse Longitudinal Data. Journal of the American Statistical Association, 100(470): DOI: 10.1198/016214504000001745.

[0232] All percentages and ratios are calculated by weight unless otherwise indicated.

[0233] All percentages and ratios are calculated based on the total composition unless otherwise indicated.

[0234] It should be understood that every maximum numerical limitation given throughout this specification includes every lower numerical limitation, as if such lower numerical limitations were expressly written herein. Every minimum numerical limitation given throughout this specification will include every higher numerical limitation, as if such higher numerical limitations were expressly written herein. Every numerical range given throughout this specification will include every narrower numerical range that falls within such broader numerical range, as if such narrower numerical ranges were all expressly written herein.

[0235] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as "20 mm" is intended to mean "about 20 mm."

[0236] Every document cited herein, including any cross referenced or related patent or application, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0237] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

1. A method for treating an individual at risk for non-linear lung function decline, comprising
  a) determining one or more covariates associated with lung function in said individual, said covariate being selected from one or more of a clinical measure, a biomarker or an imaging marker;
  b) calculating a risk probability score based on said determining of one or more covariate, said risk probability score being used to characterize an individual as having no predicted lung impairment, mild predicted lung impairment, moderate predicted lung impairment, or severe predicted lung impairment; and
  c) treating said individual characterized as having mild predicted lung impairment, moderate predicted lung impairment, or severe predicted lung impairment with one or more of increased frequency of disease monitoring, increased frequency of infection monitoring, anti-inflammatory therapy, or combinations thereof.

2. The method of claim 1, wherein said risk probability score comprises a risk probability of a clinical outcome